CANMET

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Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

SUMMARIES OF CANMET ENERGY RESEARCH CONTRACTS 1982-1983

COMPILED BY T.P. LANZER

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FOREWORD

This report summarizes energy related R & D contracts which were sponsored by CANMET and completed in 1982 and 1983. The summaries were prepared to assist in transferring to industry the new technology which has been created through CANMET's extensive contracting-out program. In fiscal year 1982-83, the value of energy related R & D which was contracted-out exceeded $8.5 million, representing 23% of the CANMET Energy Technology Activity budget for the year. Energy contracts completed prior to 1982 were summarized previously in CANMET Reports 78-1, 79-26 and 82-11.

Final reports for the contracts outlined in these summaries are available through the Technology Information Division, Canada Centre for Mineral and Energy Technology (CANMET), Department of Energy, Mines and Resources, 555 Booth Street, Ottawa, Ontario, K1A 0G1; Telephone: (613)995-4029, TELEX: 053-3395.

The CANMET Research Program Office is grateful to Tom Lanzer of the University of Ottawa for diligently assembling this report during the summer of 1983.

D.A. Reeve
Director
Energy Program Office

AVANT-PROPOS

Ce rapport décrit, sous forme de résumés, les contrats de R et D énergétique qui on été adjugés par CANMET et exécutés en 1982-1983. Les résumés ont pour but de faciliter le transfert, au profit de l'industrie, des nouvelles techniques qui ont vu le jour grâce au vaste programme d'adjudication de CANMET. Au cours de l'exercice 1982-1983, plus de 8,5 millions de dollars de contrats ont été accordés à l'entreprise dans le domaine du R et D énergétique; ce chiffre représente 23% du budget alloué à l'activité "Technologie énergétique" pour cette année-là. Les descriptions de contrats achevés avant 1982 ont déjà été présentées dans les rapports 78-1, 79-26 et 82-11 de CANMET.

On peut avoir accès aux rapports définitifs des contrats décrits dans ces résumés en s'adressant à la Division de l'information technologique, Centre canadien de la technologie des minéraux et de l'énergie (CANMET), ministère de l'Énergie, des Mines et des Ressources, 555, rue Booth, Ottawa, (Ontario), K1A 0G1; téléphone: (613) 995-4029, TÉLEX: 053-3395.

Le bureau du Programme de recherche de CANMET est reconnaissant à Tom Lanzer, de l'Université d'Ottawa, d'avoir soigneusement colligé ce rapport au cours de l'été 1983

D.A. Reeve
Directeur
Bureau du Programme de recherche

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ENERGY TECHNOLOGY

CONSERVATION

TITLE: LASER-DOPPLER VELOCIMETER COMBUSTION INVESTIGATION

CONTRACTOR:	University of Toronto	FILE NUMBER:	0-9050	FUNDING	
		BEGIN/END:	Sept. 80/March 82		
				CANMET:	$45 000
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Conservation	OTHER:	--
AUTHORITY:	Dr. J. Lau	TECHNOLOGY:	Oil and Gas Combustion	TOTAL:	$45 000

OBJECTIVES

Develop an experimental means of measuring droplet size distribution and droplet velocity distribution in practical liquid sprays using Laser-Doppler Velocimeter (LDV) techniques.

PROCEDURE

Acquire and set up a laser and detection system for measuring scattered light from particles. Signals from particles with known size and velocity traversing the measurement volume, are processed by a microcomputer to give direct measurement of size and velocity.

RESULTS

Within certain limitations of particle sizes and receiving aperture, the calibration runs with known size, and velocity particles show very good agreement with measured values.

APPLICATION AND ONGOING WORK

This technique is useful for studying fuel sprays in combustion devices and work continues along this line.

TITLE: ENERGY CONSERVATION IN THE INDUSTRIAL MINERALS PROCESSING SECTOR: COMMINUTION

CONTRACTOR:	SNC Inc.	FILE NUMBER:	1-9094	FUNDING	
		BEGIN/END:	March 82/May 82		
				CANMET:	$19 902
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Conservation	OTHER:	--
AUTHORITY:	L. Sirois	TECHNOLOGY:	Energy Conservation in Industrial Processes	TOTAL:	$19 902

OBJECTIVES

To develop the necessary technology to optimize industrial mineral comminution (crushing and grinding) circuits in terms of direct and indirect energy consumption.

In order to develop the means to optimize comminution circuits in terms of total energy consumption, a state-of-the-art review is required and should include:

1. Comminution technology as applied to industrial minerals.
2. Comminution circuit control technology.
3. The requirements and specifications of the major processors and users of industrial minerals as they relate to those particulate properties influenced by comminution.

PROCEDURE

The data are to be compiled from the technical and research literature, the manufacturers of relevant equipment and by consultation with specifications committees, user organizations and individual users and processors of industrial minerals (e.g., PCA, Glass Research Council, Clay Brick Associates of Canada, CSA, ASTM).

RESULTS

Energy conservation in comminution for the industrial minerals processing sector can be achieved in a number of ways. The potential for energy conservation rests on the proper selection of machinery, control of the input characteristics of the feed and definition of the finished product requirements. Since the constraints differ from industry to industry in the sector, the optimization of the components to conserve energy requires that proper selection of machinery be made for each specific industry.

Some basic rules are applicable to the optimization of comminution circuits. These rules require that the installed machinery power be fully utilized and that the feed supplied be homogeneous and continuous. Because the specific power consumption for crushing is lower than that for grinding, the over-all energy consumption in a comminution circuit would be reduced if the range of the crushing were increased. This will result in the reduction of specific power consumption because of reduction in the amount of grinding. Furthermore, the application of process control to the entire comminution process would yield appreciable savings in energy consumption provided the operating parameter of a given installation is known and defined.

The conventional energy-related laws have proved to be insufficient to predict the results of complex comminution operations. Mathematical models used to simulate the elements of comminution have yielded encouraging results. Simulation techniques, in conjunction with scaled-up operating data of "in production" comminution processes, are likely to advance the method of predicting the final results.

APPLICATION AND ONGOING WORK

This work is being continued by a contract which will demonstrate the possibilities of energy conservation through the application of the principles outlined in this report.

ENERGY TECHNOLOGY

PETROLEUM SUPPLY

TITLE: INVESTIGATION OF A MODULAR APPROACH TO THE DEVELOPMENT OF A SURFACE TAR SANDS MINING OPERATION - PHASE 1

CONTRACTOR:	Techman Engineering Ltd.	FILE NUMBER:	2-9131	FUNDING	
		BEGIN/END:	Sept. 82/Feb. 83		
				CANMET:	$449 213
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	OTHER:	--
AUTHORITY:	V. Srajer	TECHNOLOGY:	Bitumen and Heavy Oil Recovery	TOTAL:	$449 213

OBJECTIVES

1. Examine the small scale approach to development of a tar sands property.
2. Specify the governing logic.
3. Define a framework for carrying out the concept to the demonstration stage.
4. Display the findings to a range of discriminating users.
5. Elaborate on the potential industrial benefits to Canada.

PROCEDURE

1. Identify the characterizing features and constraints of a "MegaProject" and "Modular Project" approach to development of a tar sands property. Document, for a megaproject, the significant parameters such as capital cost per daily stream barrel, total cost, cash flow profile, environmental considerations, available technology and any other significant descriptive parameters.
2. Identify the economic, operational and technological criteria for a modular small scale project and state these in the form of absolute and desirable requirements.
3. Identify probable schemes for examination (for example a 15 000 BPD module) and outline a development scenario including preliminary budgets and schedules, to test the schemes versus the criteria previously established.
4. Select surface mineable tar sands development schemes that demonstrate a probability of success, and develop a study program for detailed evaluation and ranking of the selected schemes.
5. Prepare presentation material to display the preliminary conclusions and proposed future study program to audiences selected by the government.

RESULTS

Based on the comparative analysis of the selected cases, the preliminary conclusions arising out of the Phase 1 analysis are:

1. A smaller scale, fully integrated plant appears relatively attractive on the basis of maximum economic performance and minimum financial exposure as measured by payback time and sunk capital.
2. A build-up case, where the operator makes an initial investment in a smaller plant, and subsequently expands to a large plant partially financed out of cash flow generated by the smaller plant, appears attractive.
3. A modular mining concept, based on the innovative use of mobile equipment in a way that minimizes haul distances, has been developed by Techman Engineering Ltd., and appears particularly suitable for smaller developments or build-up cases.
4. New mining and extraction facilities supplying bitumen to Syncrude Canada Ltd., Suncor Inc. or to certain existing Edmonton area refineries, appear to have good potential.

APPLICATION AND ONGOING WORK

Phase 2 of the study will examine the technical, economic, environmental and social credibility of a modular oil sands mining and extraction scheme by defining the optimum size of the module and scale-up characteristics of that module.

TITLE: CHEMICAL CHARACTERIZATION OF THE POLYNUCLEAR AROMATIC HYDROCARBONS IN FRACTIONS BOILING ABOVE 350°C

CONTRACTOR:	United Technology and Science Inc.	FILE NUMBER:	0-9175	FUNDING	
		BEGIN/END:	Sept. 81/Aug. 82		
				CANMET:	$78 755
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	—
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	OTHER:	—
AUTHORITY:	M.A. Poirier	TECHNOLOGY:	Characterization of Bitumen and Heavy Oils	TOTAL:	$78 755

OBJECTIVES

Polynuclear aromatic hydrocarbons are the predominant aromatic type in bitumens, heavy oils and their synthetic heavy products. They have the potential to play a significant role in coke deposition in reactors during upgrading processes. Detailed study of the chemistry of PNA's present in the processing products of increasing processing severity, as well as at different levels in the reactor, could give insight into the role of PNA's in the mechanism of coke formation.

PROCEDURE

Chemical characterization of the PNA's in six samples as follows:

1. Preparation of samples by distillation and deasphaltening to obtain the maltene fraction of the residues boiling above 350°C.
2. Hydrocarbon-type separation (saturates, monoaromatics, diaromatics, polyaromatics and polar material) of these residues and using the polyaromatic concentrate for further investigation.
3. Using High Performance Liquid Chromatographic (HPLC) sorbent-mobile phase system for separation of polynuclear aromatics according to fused aromatic ring number.
4. Chemical characterization of the separated polynuclear aromatic subclasses using instrumental analysis.

RESULTS

1. Distillation and deasphaltening
2. Hydrocarbon-type separation
3. Acid-base fractionation of PAH concentrate
4. Ring size separation by HPLC
5. Molecular size separation
6. Elemental analysis
7. HPLC-Fluorescence and HPLC-UV analysis
8. Capillary GC-FID and GC-MS analysis

APPLICATION AND ONGOING WORK

Results are detrimental for correlation of the coke formation in the reactor during hydrocracking.

No ongoing work at this moment.

TITLE: **DEVELOPMENT OF CATALYSTS FOR HYDROGENATION OF CONDENSED POLYNUCLEAR AROMATIC COMPOUNDS**

CONTRACTOR: Guelph Chemical Labs Ltd.

FILE NUMBER: 9-9106-1
BEGIN/END: March 81/May 82

CANMET SCIENTIFIC AUTHORITY: Dr. M. Ternan

ENERGY TECHNOLOGY ACTIVITY
SUB-ACTIVITY: Petroleum Supply
TECHNOLOGY: Upgrading Synthetic Crudes to Transportation Fuels

FUNDING

CANMET:	$24 500
CONTRACTOR:	—
OTHER:	—
TOTAL:	$24 500

OBJECTIVES

1. Construct a flash hydropyrolysis apparatus and a formic acid hydrogenation apparatus.
2. Develop quantitative analytical procedures.
3. Flash hydropyrolysis experiments were to be performed:
   a) with phenanthrene at 4 temperatures and 3 residence times, and
   b) with naphthalene and anthracene at 3 residence times.
4. Formic acid hydrogenation experiments on phenanthrene using formic acid and t-butyl amine as cosolvents.
5. Prepare a final report describing the results of the above experiments.

PROCEDURE

1. The flash hydropyrolysis unit was to be built from stainless steel. Hydrogen flowed through the reactor which contained a batch of the condensed polynuclear aromatic compound.
2. Formic acid hydrogenation was to occur in a stirred glassware vessel.
3. Rapid heating for flash experiments was to be obtained by electric heating using storage batteries.

RESULTS

1. The formic acid hydrogenation experiments were completely negative. No hydrogenation of the condensed polyaromatic compounds occurred.
2. During flash hydropyrolysis experiments, conversions of up to 80% were obtained for phenanthrene and anthracene. Conversions of naphthalene were typically 40%.
3. Material balances indicated that not all of the reaction products were being collected. Therefore, conversions had to be calculated based on the amount of unreacted feedstocks.
4. It was concluded that a more sophisticated experimental apparatus (which was outside the scope of this study) would be required to obtain accurate material balances.

APPLICATION AND ONGOING WORK

Continuation of additional work by contract, in order to obtain reliable material balances, is under discussion.

TITLE: CONCEPTUAL DESIGN FOR A FULLY AUTOMATED ULTRASONIC TESTING SYSTEM CAPABLE OF DETECTING AND SIZING WELD DEFECTS - PHASE 1

CONTRACTOR:	Welding Institute of Canada	FILE NUMBER:	9-9018	FUNDING	
		BEGIN/END:	July 79/March 80		
				CANMET:	$39 940
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	OTHER:	--
AUTHORITY:	V. Caron	TECHNOLOGY:	Materials for Hydrocarbon Processing	TOTAL:	$39 940

OBJECTIVES

This work is part of a broad CANMET project whose objective is the upgrading of Canadian capabilities in the manufacture of thick-wall pressure vessels.

Phase 1 - The objective of Phase 1 was to develop a conceptual design for a fully automated ultrasonic testing system, capable of detecting and sizing weld defects in heavy-section pressure vessels, especially for use in the petrochemical processing industry.

PROCEDURE

1. A state-of-the-art survey, which included visits to continental European centres of excellence in NDT, reviewed the existing technology and pointed out the trends in the advanced ultrasonic methods applicable to the inspection of thickwall pressure vessels.
2. Limited experimental work was done using both artificial and natural defects in a 15.25 cm thick welded sample. Both radiography and ultrasonics testing was applied. Focussed probes were also used.
3. From the above results, flaw signal levels were determined for automated data handling.

RESULTS

Two reports were prepared. The work completed led to the conceptual design of an automated inspection system claimed to be capable of scanning pressure vessels of up to 15.25 cm wall thickness without cladding. For the proposed system, the Z-80 based microcomputer will provide the scanning control and data acquisition functions. The system would also be adjustable for different weld geometries.

TITLE: DEVELOPMENT OF AN AUTOMATED ULTRASONIC TESTING SYSTEM FOR THE DETECTION AND SIZING OF WELD DEFECTS IN HEAVY SECTION PRESSURE VESSEL STEELS - PHASE 2

CONTRACTOR:	Welding Institute of Canada	FILE NUMBER:	9-9110	FUNDING	
		BEGIN/END:	June 80/March 81		
				CANMET:	$44 405
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	OTHER:	--
AUTHORITY:	V. Caron	TECHNOLOGY:	Materials for Hydrocarbon Processing	TOTAL:	$44 405

OBJECTIVES

Based on the conceptual design of Phase I:

1. Construct an automated ultrasonic testing system for the detection and sizing of weld defects in heavy section pressure vessel steels.

2. Carry out a laboratory evaluation and make any appropriate modifications so that the system be ready for trials or applications.

PROCEDURE

1. Construction was completed and the unit is operational. Tests were limited to one submerged-arc weld (SAW), as agreed.

2. Scanning tests were run on artificial defects and calibrating holes in thick plate (150 mm). Signal acquisition and handling were tested along with scanning equipment stability.

3. By means of A-scans, lateral and range resolutions were determined.

RESULTS

1. Although the system is not field-ready, the concepts and capabilities were established. More work is needed, particularly on the data processing system.

2. The resolving power for defect sizing varied from 3-5 mm in the volume to about 10 mm near the surface. It can detect any reflector larger than 5-6 mm.

3. Improvements were identified for both the ultrasonic testing and the data processing systems for an eventual industrial version.

4. The estimated cost of a commercial unit would be about $150 000.

TITLE: STATE-OF-THE-ART REVIEW OF NONDESTRUCTIVE EXAMINATION TECHNIQUES FOR ON-LINE INSPECTION OF PIPELINES FOR SUB-CRITICAL CRACKS - PHASE 2

CONTRACTOR:	Welding Institute of Canada	FILE NUMBER:	9-9127	FUNDING	
		BEGIN/END:	June 80/Jan. 81		
				CANMET:	$14 955
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	OTHER:	--
AUTHORITY:	V. Caron	TECHNOLOGY:	Materials for Oil and Gas Pipelines	TOTAL:	$14 955

OBJECTIVES

Complete a state-of-the-art review of the methods applicable to on-line measurements of sub-critical flaws in pipelines using intelligent pigs.

A program of relevant research projects was to be submitted.

PROCEDURE

The survey included:

1. Search of available literature
2. Meeting and discussing with workers in the oil and gas industries
3. Gathering information from producers of commercial equipment

RESULTS

The report summarizes information on techniques and equipment used for on-line inspection for the range of defects found in pipelines. Methods particularly suitable for crack inspection were reviewed and their potential and limitations indicated.

Research activities are mainly carried out by major pipeline utilities.

Four proposed research programs are outlined:

1. Eddy currents
2. Ultrasonics for cracks in weld region
3. Residual magnetic fields
4. Improved data processing for the magnetic-flux leakage techniques

TITLE: DESIGN AND FABRICATION OF AN AIRBORNE REMOTE-SENSING SYSTEM FOR GAS PIPELINE LEAK DETECTION

CONTRACTOR:	Moniteq Ltd.	FILE NUMBER:	0-9103	FUNDING	
		BEGIN/END:	June 81/March 82		
				CANMET:	$ 28 134
CANMET		ENERGY TECHNOLOGY ACTIVITY		DSS:	150 000
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	MOT:	25 500
AUTHORITY:	Dr. S.M. Till	TECHNOLOGY:	Materials for Oil and Gas Pipelines	TOTAL:	$203 634

OBJECTIVES

Design, fabricate and test (both in the laboratory and in the field) an airborne remote-sensing system for the detection of gas escaping from leaks in gas-transmission pipelines. The Gas Pipeline Leak Sensor (GASPILS), with two channels to simultaneously monitor ethane and methane, will be designed to operate properly in the severe operating environment normally found in aircraft and helicopters. Design, fabrication, and testing will be done to prove, document, and extend the range of useful operation of the sensor over as many atmospheric, seasonal, and surface conditions as possible.

PROCEDURE

Phase 1 - Conceptual Design

1. Assessment of gas filter correlation technique
2. Model calculation
3. Signal to noise and detectivity calculation
4. Optical conceptual design
5. Signal processing design
6. Mechanical design
7. Calibration and test plan

Phase 2 - Detailed Design, Fabrication and Laboratory Testing

1. Optical and mechanical design, including detailed drawings
2. Electronics and signal processing design
3. Laboratory performance testing
4. Full sensor documentation (design, test data, operation etc.)

RESULTS

The development has gone well. The sensor design has been debugged and a laboratory demonstration has shown that the conceptual design is good. The several novel features of the design (gas-cell thermalization, cell-chopping sequence, and construction, electronic balancing and data processing logic, etc.) have all been validated.

The sensor's performance has also been validated. Methane detection performance is fully that which was expected and a study of performance suggested some changes (size of detector, chopping frequency, detector cooling method, etc.) which are capable of making the sensor even more sensitive in this channel.

The ethane channel has been validated and has performed correctly. In the case of ethane, the sensitivity is less than expected, although there are additional features on the channel which will be pursued to improve the sensitivity.

APPLICATION AND ONGOING WORK

Application - Detection of gas pipeline leaks, with improved cost effectiveness, using an airborne system to greatly increase the monitoring rate of the pipelines.

Ongoing work - Considerable interest in the system has been expressed by some pipeline companies and gas utilities. It is hoped that funding will be available for field testing and evaluation of this prototype system with the possibility of future manufacture of a production item.

TITLE: CORROSION FATIGUE OF TUBULAR JOINTS FOR OFFSHORE STRUCTURES

CONTRACTOR:	Memorial University of Newfoundland	FILE NUMBER:	1-9090	FUNDING	
		BEGIN/END:	Dec. 81/Jan. 83		
				CANMET:	$54 624
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	OTHER:	--
AUTHORITY:	O. Vosikovsky	TECHNOLOGY:	Materials for Offshore Structures	TOTAL:	$54 624

OBJECTIVES

1. Determine experimentally, and by finite element analysis, the stress concentration in monopod tubular joints.

2. Determine the effect of cold sea water (0°C) and weld toe grinding on the fatigue life of model moncpod tubular joints, and compare the measured life with relevant current data.

PROCEDURE

1. The stress concentration was determined by strain gauges on each tested model and by finite element analysis using the MSC/NASTRAN program.

2. Four model tubular joints were tested in cold sea water, three under constant load amplitude, one under random amplitude loading. Two joints were as-welded, two had ground weld toes.

RESULTS

1. The stress concentration factors determined experimentally and by finite element analysis are in close agreement (between 9 and 11.8).

2. The cold sea water environment did not have any significant effect on fatigue life as compared to air. The expected improvement in fatigue life due to weld toe grinding was not confirmed by tests, possibly because the walls in the models were too thin and grinding resulted in excessive reduction of wall thickness.

APPLICATION AND ONGOING WORK

The results contribute to the reliable determination of S-N curves used in fatigue design of tubular joints for offshore exploration and production platforms.

In the follow-up contract, the stress distribution in tubular joints is examined using finite element analysis.

TITLE: SURVEY OF REQUIREMENTS FOR PLATE STEELS IN OFFSHORE STRUCTURES AND ARCTIC VESSELS

CONTRACTOR:	Chinook Fuel Innovations Ltd.	FILE NUMBER:	1-9102	FUNDING	
		BEGIN/END:	Dec. 81/Oct. 82		
				CANMET:	$38 949
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Petroleum Supply	OTHER:	--
AUTHORITY:	Dr. J.D. Boyd	TECHNOLOGY:	Materials for Offshore Structures	TOTAL:	$38 949

OBJECTIVES

1. Survey of current and forecast demand to the year 2000 for offshore structures and Arctic vessels, by type, size and quantity.
2. Identification of thick plate (>25 mm) requirements in current and future structures and vessels by specification, fabrication, use and amount.
3. Evaluation of the capabilities of Canadian manufacturers and fabricators to meet the demand for thick plate.
4. Identification of technology barriers and relevant research problems.

PROCEDURE

1. Survey of published literature.
2. Interviews with operating companies, project sponsors, steel makers, naval architects, engineers and fabricators.
3. Interpretation, evaluation and development of data based on information from various sources.

RESULTS

A comprehensive evaluation of the number of vessels and structures to be built for frontier mining and petroleum projects to the year 2000 was completed. A general description of each design is given and the required tonnage of steel plate is estimated for different grades and thicknesses.

The total tonnage demand for thick steel plate - 25 mm and thicker - in the three major steel grades, to the year 2000, is forecast as follows:

- Steel Grade E: 42 260 tonnes.
- Steel Grade EH36 (incl EH modified): 192 250 tonnes.
- Low Temperature Steel: 146 485 tonnes.

Broken down by thickness ranges:

- 25-37 mm range: 223 080 tonnes.
- thicker than 38 mm: 157 915 tonnes.

To provide the Canadian shipbuilding industry with greater opportunity in bidding against foreign competitors for Canadian ships requires a substantially remodelled financial aid package which includes primarily, a short-term low-interest loan for the duration of the construction period. To position Canada at the top of international technology for low-temperature or Arctic structures and vessels, establishment of a comprehensive cold regions data bank is necessary. These data would be accessible to all interested parties - steelmakers, shipbuilders and fabricators, naval architects, designers and engineers, project operators, equipment manufacturers and service firms.

APPLICATION AND ONGOING WORK

This report will be used as a reference for planning CANMET research projects on materials for offshore structures and Arctic vessels.

ENERGY TECHNOLOGY

COAL

TITLE: DEVELOPMENT, INSTALLATION AND OPERATION OF A SUBSIDENCE MONITORING AND TELEMETRY SYSTEM

				FUNDING	
CONTRACTOR:	Ecological and Resources Consultants Ltd.	FILE NUMBER:	8-9016		
		BEGIN/END:	March 79/Aug. 81		
				CANMET:	$103 630
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	—
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	—
AUTHORITY:	Dr. M.Y. Fisekci	TECHNOLOGY:	Mining	TOTAL:	$103 630

OBJECTIVES

Develop, install and operate a subsidence-monitoring and telemetry system for the rugged terrain and difficult winter conditions of the Rocky Mountain region of Western Canada.

PROCEDURE

1. Construct and test the prototype at the contractor's site.

2. Install the prototype system over the No. 6 panel of the new hydraulic mine located in the vicinity of Sparwood, B.C. The system will consist of five monitors/sensors and be capable of remote monitoring by radio frequency.

RESULTS

Contract work on the development of a subsidence telemetry system was successfully completed. Final installation of the subsidence telemetry network was also completed. The network is in operation to monitor the subsidence at selected points over the hydraulic mine during 1981-82-83 until settlement is complete.

APPLICATION AND ONGOING WORK

New contracts were let to maintain and upgrade the system as well as test new sensors for underground.

TITLE: CHARACTERISTICS OF OVERBURDEN IN ALBERTA AND SASKATCHEWAN PLAINS COAL FIELDS THAT WOULD LIMIT APPLICATION OF BUCKET WHEEL EXCAVATORS

CONTRACTOR:	North American Mining Consultants Inc.	FILE NUMBER:	9-9148	FUNDING	
		BEGIN/END:	July 80/March 81		
				CANMET:	$60 000
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	V. Srajer	TECHNOLOGY:	Mining	TOTAL:	$60 000

OBJECTIVES

Identify characteristics of overburden material in Alberta and Saskatchewan plains coal fields that would limit application of bucket wheel excavators.

PROCEDURE

1. Review experience with bucket wheel mining systems and identify those factors critical to application in Alberta and Saskatchewan coal fields.
2. Identify standard tests and overburden exploration necessary to apply bucket wheel excavators to plains coal fields.
3. Review pertinent geological, hydrogeological, topographical, and climatic information on plains coal fields.
4. Identify appropriate overburden components and evaluate cutting-resistance factors.
5. Specify areas or mining properties most favourable to bucket wheel mining.

RESULTS

Bucket wheel excavators can be applied to all plains coal mines in Alberta and Saskatchewan. The bulk of overburden in all plains coal mines is amenable to efficient removal with a bucket wheel excavator. Several mines have tougher layers which may require removal with auxiliary equipment.

The report recommends the Wabamun, Alberta, coal area as the most suitable for the application of bucket wheel excavators. The report also includes tables of cutting-resistance values of overburden material from Alberta and Saskatchewan coal fields.

APPLICATION AND ONGOING WORK

The study is being used by Transalta Utilities Ltd. of Calgary to evaluate their Highvale Mine for application of bucket wheel excavators.

TITLE: ASSESSMENT OF NOVA SCOTIA COAL PREPARATION PROBLEMS

CONTRACTOR:	Atlantic Coal Institute	FILE NUMBER:	0-9082	FUNDING	
		BEGIN/END:	Feb. 81/June 82		
				CANMET:	$18 000
CANMET		ENERGY TECHNOLOGY ACTIVITY		DSS:	20 000
SCIENTIFIC		SUB-ACTIVITY:	Coal	DEVCO:	25 000
AUTHORITY:	L.L. Sirois	TECHNOLOGY:	Preparation	TOTAL:	$63 000

OBJECTIVES

1. Determine the types of sulphur in Nova Scotia Coal Mines (organic, pyrite or other sulphates) and accumulate data on the quantity, size, and segregation of this sulphur.

2. Determine if other undesirable elements, such as uranium, exist in the Nova Scotia coal fields and correlate data to predict the quantities and variability of such constituents.

3. With the data from 1 & 2 and analysis of new drill core samples, establish an assessment of future problems.

4. Correlation and assessment of work done to date on sulphur removal from coal or coke (DEVCO, SYSCO, AGRIM participants).

5. Economic assessment of different types of coal preparation and other options, such as fluidized bed and flue gas desulphurization, which can be used to treat Nova Scotia coals.

PROCEDURE

1. Established correlation coefficients with distance in four directions from sulphur analysis done on channel samples.

2. Determined percentage of organic sulphur versus other sulphur constituents in mined areas.

3. Correlated work done to date on various elements such as uranium with depth and mine location.

4. Determined relationship of sulphur forms in channel samples with sulphur in sink-float component.

5. Determined the total amount of sulphur in the coal and the relationship between sulphur forms in coal of various specific gravities.

6. Assessed work done to date on sulphur removal by the Cape Breton Development Corp., in its coal preparation practice.

RESULTS

1. The data shows the wide fluctuations in sulphur content within the seam from roof to floor and also between the different sample locations.

2. Values of total sulphur, within the seam, as in Channel Sample No. 5, vary from 6.91% to 0.54% and again in Channel Sample No. 2, from 3.32% to 0.5%.

3. The average total sulphur values of the channel sample locations ranged from 3.23% in Sample No. 4 to 1.02% in Sample No. 1.

4. There is a pattern of increased sulphur in the top and bottom of the seam.

5. Although the sulphur values vary for both pyritic and organic sulphur, the organic sulphur could be considered relatively constant in comparison to the pyritic sulphur. Thus, where the total sulphur shows a significant increase, this is due, in general, to a corresponding increase in pyritic sulphur.

6. A weighted arithmetic average of all samples shows the total sulphur to be 2.07%, the pyritic sulphur 1.45% and organic sulphur 0.62%.

7. No significant variations in sulphur content in relation to distance, both north-south and east-west, could be established, and no pattern emerged.

8. The possibility of a linear relationship between total sulphur and total iron was investigated.

9. All correlations were significant, however, the bounds of error in predicting total sulphur in terms of iron were large, and not very useful for measuring sulphur during operations of the coal preparation plant.

10. This report suggests that trace element levels for coal samples from the Sydney coal field are roughly comparable to other coal deposits of similar rank in the U.S. Comparison of the concentration ranges of 16 Nova Scotia raw coals with those of various bituminous coals is given.

APPLICATION AND ONGOING WORK

Report distributed to interested organizations. Ongoing work will continue through the Atlantic Coal Research Group.

TITLE: THERMAL DEWATERING OF LIGNITE - PHASE 4

CONTRACTOR:	Saskatchewan Power Corp.	FILE NUMBER:	0-9158	FUNDING	
		BEG.N/END:	Oct. 81/March 82		
				CANMET:	$105 117
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	105 117
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	Dr. J. Price	TECHNOLOGY:	Preparation	TOTAL:	$210 234

OBJECTIVES

Examine the feasibility of developing a lignite beneficiation facility in Saskatchewan that would provide a dry, clean fuel with more reduced slagging and fouling properties than the non-beneficiated lignite. The beneficiated lignite would be easier to handle, have reduced shipping costs and would reduce boiler size requirements.

PROCEDURE

1. Assess the state of development of the process.
2. Develop a conceptual design for a 150 t/h lignite beneficiation facility.
3. Develop cost estimates for the process and facilities.
4. Perform a market survey and economic analysis of the process.
5. Provide a project appraisal and recommendation for future research and development of the project.

RESULTS

In the process, slurried ROM lignite is held at 350°C in a reactor for 12 min in the presence of pressurized, saturated steam. The equilibrium moisture is reduced to 14.8% (from 33.5% for ROM lignite), sulphur and alkali metals are reduced by more than 50%. Heating value is increased by about 6%, and the lignite is no longer subject to spontaneous combustion.

The total plant cost was estimated to be $176 million. For $10/t ROM lignite and 5% DCF ROI, the product price is $42.55/t. In addition to benefits as a result of higher heating value and reduced water content (resulting in decreased transportation charges), other cost savings are foreseen as a result of reduced sulphur and alkali metals content. These savings are: general utility costs (maintenance, availability, and capital costs) $0.56/t ROM lignite; slagging and fouling $0.32/t ROM lignite; and sulphur removal $6.14/t ROM lignite.

Of the potential users and markets identified (SPC, other Saskatchewan consumers, Ontario, and the Pacific Rim countries), Ontario appears to be the most attractive, with a projected requirement of 4.7 million tonnes of lignite by the year 2000.

In addition to the utilities, small industrial users could benefit from the use of beneficiated lignite, as improvements in performance and cost savings are greater for smaller, less efficient boilers.

APPLICATION AND ONGOING WORK

Phase 5 is being undertaken to determine if the reactor temperatures can be reduced substantially and to obtain more precise data on the BOD levels of the effluent water. These parameters significantly influence the overall capital cost of the project.

The completed contracts in this series have been summarized in previous reports:

Phase 1: File No. 7-9128
Phase 2: File No. 8-9125-5
Phase 3: File No. 9-9164

TITLE: ALGOMA STEEL CORPORATION LTD No. 6 BATTERY RESEARCH PROGRAM

CONTRACTOR:	Algoma Steel Corporation	FILE NUMBER:	1-9113	FUNDING	
		BEGIN/END:	Feb. 82/March 83		
				CANMET:	$162 700
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	162 700
SCIENTIFIC		SUB-ACTIVITY:	Coal	DSS:	162 700
AUTHORITY:	J.F. Gransden	TECHNOLOGY:	Carbonization	TOTAL:	$488 100

OBJECTIVES

Excessive gas pressure in coke ovens damages or destroys the heating walls, placing limits on productivity and coke quality. The objective is to define the limits of safe operation.

PROCEDURE

An industrial coke oven battery, in operation but due for replacement, was used to coke potentially dangerous blends of coals under different operating conditions. Gas pressures and temperatures at the centre of the oven were measured continuously and other operating data recorded.

RESULTS

The gas pressures recorded were used to determine the maximum forces on the walls of the oven. Safety limits for the coal blends and operating practices used were then defined. A number of commercially useful blends, previously believed to be unsafe, were identified.

APPLICATION AND ONGOING WORK

Gas pressures in pilot-scale ovens during coking of the industrial blends are being obtained so they can be related to the industrial pressures. The pilot-scale ovens can then be used to define blend safety.

TITLE: LIGNITE REACTIVITY - PHASE 3

CONTRACTOR:	Saskatchewan Power Corp.	FILE NUMBER:	9-9153	FUNDING	
		BEGIN/END:	May 80/Nov. 81		
				CANMET:	$97 455
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	L. Mysak	TECHNOLOGY:	Gasification	TOTAL:	$97 455

OBJECTIVES

Determine the distribution of toxic trace elements in tar, ash, and gas during the process of gasification to assess their potential impact on the environment.

The results obtained for the effluent streams were compared with several full-scale and pilot gasifiers.

PROCEDURE

1. An existing batch reactor (51 mm internal diameter) was modified to permit continuous feeding of coal into the reactor.

2. Coronach and Estevan lignites were gasified with air-steam mixtures under various operating conditions. Product gases were collected at regular intervals and analyzed by gas chromatography. Residual ash was analyzed for carbon content and major and minor ash constituents. Tar samples were analyzed to determine the effect of process variables on the composition and formation of tar.

3. Toxic trace elements in coal, tar, ash, and gas were determined for three selected samples of each coal.

RESULTS

The composition of condensates, collected during gasification of Saskatchewan lignite coals, compares well with the composition of gasifier sluice water and quench water obtained from large scale fixed-bed gasifiers. Comparison of heavy element concentrations with those allowable under the Canadian Drinking Water Objectives and the U.S. Standards shows that only those for arsenic, boron, and chromium are exceeded. The high chromium levels are thought to arise from the reactor due to a high surface area to volume ratio in bench scale reactors. The higher arsenic and boron levels are thought to be directly related to their high levels in Canadian lignites. The organic content of the condensate is similar to that observed in other fixed-bed gasifiers.

Elements such as mercury, selenium, lead, fluorine, and antimony do not show an enrichment in the ash residue as compared to their levels in the parent coal. This indicates a high degree of volatility for these elements. Arsenic does not show this anticipated effect. The potential environmental problems associated with gasifier ash are those of leaching and are similar in nature to those encountered in ash disposal for conventional coal fired facilities.

APPLICATION AND ONGOING WORK

Since there is a lack of experience in both Canada and the U.S. with coal gasification plants, the quantities and significance of emissions are not well established or understood. This work identifies potential hazards from toxic trace elements in gasification solid residue and scrubber/quench waste streams.

Continuation of Phase 2 contract: File No. 8-9125-1.

TITLE: DEVELOPMENT OF FLUID BED GASIFICATION AND COAL GAS COMBUSTION CONTROL PARAMETERS FOR A RANGE OF CANADIAN COALS - PHASE 4

CONTRACTOR:	ASECOR Ltd.	FILE NUMBER:	0-9140	FUNDING	
		BEGIN/END:	June 81/March 82		
				CANMET:	$15 980
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	L. Mysak	TECHNOLOGY:	Gasification	TOTAL:	$15 980

OBJECTIVES

1. Perform fluid bed coal gasification experiments and compare results with the analytical model results.

2. Study the details of the coal gas combustion field in a gas turbine type combustor and relate the combustion characteristics to the flame structure.

PROCEDURE

A fluidized bed gasifier, with inside diameter of 7 cm and length of 98 cm, was used to obtain detailed data to be used in comparing theoretical with experimental results. An attempt was made to operate the gasifier for a reasonable period of time at steady-state conditions in order to make a meaningful comparison.

An existing combustor test rig was used to study the thermal and fluid mechanics inside the test combustor. The fuel for the combustor was obtained by blending CO, H_2, and CO_2 from gas bottles in the proportions expected for gas produced from a fluidized-bed oxygen-blown coal gasifier.

RESULTS

Despite modifications to the existing gasifier setup, it was concluded that this unit is not suitable for steady-state operation as a fluidized bed for sufficiently long periods of time to make the necessary tests to allow comparison with analytical results. Reasons for this inadequacy are discussed and recommendations for improvements which should be incorporated in a new design are outlined.

With the difficulties encountered in the experimental work undertaken, the methodology was changed to carry out instead a comparison of the analytical with the experimental results available in the literature.

A complete comparison was found to be impossible due to a lack of reported experimental data. Experimental results and operational information from commercial units are very limited and, more importantly, whenever they are available they are not complete ; missing basic information does not permit the selection of the necessary data (e.g., coal properties, independent process variables, etc.) for running the computer programs and generating the corresponding analytical results. The results obtained for the combustor were incomplete and it was not possible to reach a final recommendation or conclusion for the optimum operating conditions. However, it was possible to note that variation of the parameters chosen produced real and noticeable change. Results of temperature measurements, using an aspirated thermocouple probe, and velocity vector studies, using both a two-hole and a five-hole probe, are presented. Three components of velocity were obtained. The first few sections of the combustor showed recirculation zones and related sharp gradients in flow parameters. Thereafter, the axial velocity became quite stable, although still varying, and the circumferential and radial velocity components persisted to the combustor exit. In the work that is continuing, variation of the parameters of interest will be completed and their effect will be fully documented and comparisons made.

APPLICATION AND ONGOING WORK

To help develop Canadian expertise in coal conversion areas. Continuation of:

Phase 2 contract; File No. 8-9112
Phase 3 contract; File No. 9-9149

TITLE: TECHNICAL AND ECONOMIC ASSESSMENT OF THE RESOURCE AND ENERGY MANAGEMENT SYSTEM

CONTRACTOR: R.H. Shannon & Associates	FILE NUMBER:	0-9146	FUNDING
	BEGIN/END:	Oct. 81/Dec. 82	
			CANMET: $124 533
CANMET	ENERGY TECHNOLOGY ACTIVITY		AOSTRA: 123 666
SCIENTIFIC	SUB-ACTIVITY:	Coal	NORCEN: 123 666
AUTHORITY: M. Skubnik	TECHNOLOGY:	Gasification	TOTAL: $371 865

OBJECTIVES

This project, equally funded by CANMET, AOSTRA, and Norcen, should provide engineering evaluation, costs, and economic assessment of the production of synthetic crude oil from tar sands and/or heavy oil. Featuring the Resource and Energy Management (REM) system this project should:

1. Consider small scale production capacities ranging between 950 and 4000 m^3 of synthetic crude oil per day.

2. Compare the use of coal to natural gas as an external source of energy.

3. Apply hydrogen addition technologies for bitumen upgrading.

4. Minimize or eliminate disposal of carbonaceous solids or heavy residues and sulphurous pollutants in order to improve yield, reduce costs, and minimize the impact on the environment.

PROCEDURE

Generally, the study should only implement proven or leading technological processes of field production, recovery and upgrading of bitumen/heavy oil, gasification of heavy residues/coal, gas cleaning, electricity and steam generation by combined cycle, and production of hydrogen and oxygen by water electrolysis.

First, the contractors should define the features of production plants with Norcen and AOSTRA. Second, they should prepare basic data and requirements to be provided to the process vendors. Third, they should organize all information and design integrated plants based on:

1. Lloydminster heavy oil/natural gas, with capacity of 950 m^3 synthetic crude per day.

2. Cold Lake tar sands/Foothill coal, with capacity of 3180 m^3 synthetic crude per day.

Furthermore, they should estimate capital and operating costs, analyze possible options, and prepare economic evaluations.

RESULTS

1. The REM system with hydrogen addition upgrading may result in up to 95% yield of synthetic crude.

2. Direct operating costs may range between $75 and $88 per m^3 of synthetic crude.

3. Capital costs (1982) would be:

   Lloydminster heavy oil/natural gas
   - 950 m^3/day: $250 000 day/$m^3$

   Cold Lake tar sands/Foothill coal
   - 3180 m^3/day: $340 000 day/$m^3$

   (For comparison, similar mega-project costs would be $630 000 day/$m^3$.)

4. Small scale production plants may feature other advantages:

   a) modular concept
   b) shop fabrication of equipment
   c) start of cash flow within 3 to 4 years.

APPLICATION AND ONGOING WORK

The study was helpful in comparing the economics of this new small-scale concept to the mothballed mega-projects. Implementation of similar concepts on the Canadian scene are expected in the near future.

TITLE: FEASIBILITY OF DESIGNING A PROCESS DEVELOPMENT UNIT FOR THE COMMERCIALIZATION OF A SPOUTED BED COAL GASIFIER - PHASE 1

CONTRACTOR:	SNC Inc.	FILE NUMBER:	1-9063	FUNDING	
		BEGIN/END:	Feb. 82/Dec. 82		
				CANMET:	$79 499
CANMET		ENERGY TECHNOLOGY ACTIVITY:		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	M. Skubnik	TECHNOLOGY:	Gasification	TOTAL:	$79 499

OBJECTIVES

1. Determine the feasibility of designing a 12 t/d Process Development Unit (PDU) for spouted bed gasification of coal.
2. Prepare a preliminary design of the PDU.
3. Provide an estimate of capital and operating costs.
4. Select a possible site for erection of the PDU.

PROCEDURE

1. Review of experimental data from University of British Columbia.
2. Review of design equations and scale-up of the spouted bed reactor from a pilot plant capacity of 0.9 to 12 t/d.
3. Design of the reactor, coal storage, grinding and feeding equipment, gases and steam supply, product gas cleaning, cooling, and disposal systems for product gas and ash.
4. Estimation of capital cost and operating cost for a 3-year experimental campaign.
5. Selection of the most suitable site on the West Coast.

RESULTS

Analysis indicates the Uemaki-Kugo concept is the best fitted design equation for a spouted bed reactor. Based on the scale-up by a dimensionless model analysis method, the dimensions of the PDU reactor of 12 t/d capacity and handling coal feed particles ranging from 6.4 to 1.0 mm are as follows:

Diameter	1.0 m
Height	7.5 m
Gas Inlet Diameter	0.15 m
Total Height	9.8 m

The study recommends erection of the PDU at Duke Point Industrial Park on Vancouver Island. The PDU would cost $1 800 000 and its annual operating cost would be $1 500 000.

The contractor has also developed a mathematical model of the spouted bed coal gasifier. However, a test of the model indicates a lack of critical data such as composition, temperature and pressure drop profiles, as well as pertinent kinetic data.

APPLICATION AND ONGOING WORK

CANMET has discontinued work on the detailed design of the PDU (Phase 2). Another ongoing contract with the University of British Columbia (File No. 2-9000) should not only generate more useful data for reactor scale-up but also give evidence of the superiority of the spouted bed over other known coal gasification processes.

TITLE: POTENTIAL FOR LIQUEFACTION OF LOW RANK COALS AS A FUTURE SOURCE OF SYNTHETIC LIQUID FUELS - PHASE 2

CONTRACTOR:	Beak Consultants Ltd.	FILE NUMBER:	8-9024	FUNDING	
		BEGIN/END:	Aug. 78/March 80		
				CANMET:	$113 782
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	J.F. Kelly	TECHNOLOGY:	Liquefaction	TOTAL:	$113 782

OBJECTIVES

The major experimental objectives of the present study were to:

1. Improve Phase 1 reaction conditions by operating the autoclave system in the semi-batch mode, with incoming gas flowing through the stationary agitated slurry phase.
2. Lower the severity of operating conditions by using added catalysts.
3. Catalytically upgrade the coal-derived liquid products.
4. Compare the reactivity of Saskatchewan (Estevan) lignite with North Dakota (Zap and Gascoyne) lignites.
5. Characterize the behaviour of a simulated recycle oil.

In addition, separation and characterization techniques previously applied to coal-derived liquids were described, a review of homogeneous catalysis and its application to coal liquefaction was conducted, and a list of Canadian and U.S. patents related to coal liquefaction was provided.

PROCEDURE

Laboratory experiments were conducted on:

1. Catalytic upgrading of primary liquefaction products.
2. Comparing Estevan, Zap, and Gascoyne lignites for liquefaction behaviour.
3. Production and use of recycle oil as carrier solvent.
4. Primary catalytic liquefaction of Estevan lignite.

RESULTS

A number of interesting results were obtained:

1. Hydrogenation could only effectively occur when the nitrogen content was sufficiently low (0.3%). Oxygen was always reduced to a lower level than that present in the initial primary liquefaction feedstock; the de-oxygenation probably occurred via catalyst-aided cracking of the liquids with formation of CO_2 in all cases and sometimes CO. Hydrogen addition involved some autogeneous transfer.
2. In comparing the behaviour of the different lignites, Gascoyne was found to be the most reactive. CO was consumed in all cases except with the Zap lignite under low temperature (653°K) liquefaction conditions. The distilled fractions of the liquid products were highly oxygenated even at the light ends. H/C weight ratios ranged from 0.076% to 0.083%, for the light fractions, to 0.058% to 0.062%, for the heavy residues.
3. A simulated recycle oil was produced, composed 50% of oil derived from lignite liquefaction and 50% of oil derived from anthracene oil treated under liquefaction conditions. When using this simulated recycle oil as carrier oil for lignite liquefaction, a decrease in benzene solubles yield (from 49% to 40% at the reaction conditions tested) occurred as compared to using raw anthracene oil as carrier.
4. The primary catalytic liquefaction experiments showed similar yields at lower pressures, there by effectively reducing the severity conditions. More work will have to be done to assess the interaction between the catalyst and the hydrogen-donor properties of the carrier oil or of the resinitic material derived from the lignite. It was also observed that in order to achieve a high H-content in the liquids, a very effective prior de-nitrogenation was necessary.

APPLICATION AND ONGOING WORK

Results obtained from batch autoclave experiments are being used for the design and construction of a continuous flow coal liquefaction unit of 10 kg/h nominal capacity.

This work is a continuation of Contract No. 7-9059.

TITLE: TECHNICAL AND ECONOMIC ASSESSMENT OF THE PRODUCTION OF OIL FROM CANADIAN LOW RANK COALS - PHASE 1

CONTRACTOR:	Sandwell Beak Research Group	FILE NUMBER:	8-9125-2	FUNDING	
		BEGIN/END:	April 79/March 81		
				CANMET:	$375 854
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	375 854
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	J. Kelly	TECHNOLOGY:	Liquefaction	TOTAL:	$751 708

OBJECTIVES

Design, construct, assemble, test, and commission a 10 kg/h continuous-flow coal liquefaction unit to:

1. Provide a system capable of operating safely for extended periods of time at controlled conditions in order to produce data for scale-up to a pilot plant of 5-20 t/d capacity.

2. Have a testing tool adequate for characterization of various coals with respect to their potential as synthetic fuels feedstock.

PROCEDURE

1. Review of similar units in U.S. research organizations.

2. Formulate the design concept and operating criteria.

3. Construction and equipment selection.

4. Commissioning tests.

RESULTS

The design of the Process Development Unit (PDU) was based on the conditions at which maximum liquid yield was obtained in noncatalytic tests using lignite, anthracene oil, and CO/H_2 mixture.

A great degree of versatility was built into the unit, such as the ability to monitor either one module only or the whole process, calculating the mass and energy balances, appreciation of equipment performance, easy variation of process parameters, and modification and repair of individual modules without touching the others.

The PDU was successfully started in February 1981 and two commissioning runs were conducted before the end of the contract.

TITLE: EVALUATION AND COMPAPISON OF PRODUCTION COSTS OF LIQUID FUELS FROM COAL AND FROM OIL SANDS IN ALBERTA - PHASE 1

CONTRACTOR:	Dynawest Projects Ltd.	FILE NUMBER:	1-9059	FUNDING	
		BEGIN/END:	Feb. 82/March 82		
				CANMET:	$53 262
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	H. Sawatzky	TECHNOLOGY:	Liquefaction	TOTAL:	$53 262

OBJECTIVES

Compare an oil sand with a coal liquefaction operation in which the products are of equivalent adequacy as refinery feedstocks for the production of transportation fuels. The objectives were to make step-by-step comparisons from site preparation to the production of the final products, in which material and energy balances, environmental aspects and costs were compared. The cost comparison was considered to be the most important aspect.

It was the intention that all data for this study be taken from publications that were in the public domain.

PROCEDURE

In this study, the operations were compared at a production level of 120 000 b/d of synthetic crude. This is the scale that had been proposed for the Alsands plant. Most of the data for the oil sands plant were taken from the documents submitted to the Alberta Energy Resources Conservation Board by the Alsands consortium. In the initial phase of the study, the "H-Coal" liquefaction technology was selected and data obtained from a study made by Flour Corp. for the Electric Power Research Institute (EPRI) were used to scale-up to the 120 000 b/d capacity. Picardville sub-bituminous coal which is similar to Wyodak coal, for which much processing data were available, was considered for the liquefaction operations. The coal products were hydrotreated to a higher level than the oil sand products to ensure that they were of at least the same quality.

RESULTS

The capital costs for the mining aspects were $750 and $395 million for the oil sands and the coal liquefaction operations respectively. For the ore treatment they were $515 and $1180 million, and for the petrochemical related processing they were $1500 and $1755 million. The total capital costs of the operations were $7345 and $8070 million respectively. However, it was found that an oil sands operation in the Athabasca deposit would require a major infrastructure costing $963 million which would not be required for the coal liquefaction plant using Picardville coal.

The annual operating costs were estimated at $478 and $750 million for the oil sands and coal liquefaction plants respectively.

Cost data for upgrading coal liquid products were not available and therefore assumptions were made.

TITLE: EFFICIENCY OF THE SUPERCRITICAL GAS EXTRACTION PROCESS AS IT PERTAINS TO CANADIAN COALS - CONTINUATION

CONTRACTOR:	Raylo Chemicals Ltd.	FILE NUMBER:	0-9111	FUNDING	
		BEGIN/END:	March 81/March 82		
				CANMET:	$208 100
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	Dr. A. George	TECHNOLOGY:	Liquefaction	TOTAL:	$208 100

OBJECTIVES

1. Determine the effect of the composition of the supercritical gas on coal derived liquids (cdl) yield.

2. Determine the effect of temperatures up to 600°C and pressures up to 41.4 MPa on cdl yield.

3. Provide sufficient analytical data on the extraction products so that a preliminary evaluation can be made.

PROCEDURE

The extraction method employed is a semi-continuous method in which the crushed coal (3.175 mm maximum particle size) is placed in the reactor and the extracting medium is continuously passed through the coal bed at the desired pressure while the coal is undergoing pyrolysis.

RESULTS

Supercritical gas (scg) extraction of Forestburg subbituminous coal with toluene modified by the addition of 1 to 25% of a co-solvent was carried out in order to define the properties of an effective extraction medium. The addition of free radical initiators did not result in enhanced coal pyrolysis but did contribute to the formation of bibenzyl - a toluene degradation product. Polar compounds generally did not enhance the coal pyrolysis reaction nor aid in the recovery of coal derived liquids (cdl). Tetrahydrofuran did, however, appear to have a positive effect on cdl recovery. Solvent modification, with the hydrogen donating compound tetrahydronaphthalene (tetralin), resulted in a much greater degree of coal pyrolysis. The optimum amount of tetralin addition is about 8 to 10% on a weight basis. Two other possible hydrogen donating solvents, indane and decaline, had little or no effect on the pyrolysis of coal or the isolation of cdl.

Studies extending the temperature range of supercritical toluene extraction of Forestburg subbituminous coal led to the conclusion that the optimum extraction temperature is between 400 and 420°C. Temperatures beyond 450°C resulted in thermal polymerization of toluene. Experiments extending the pressure of the extraction to 31.0 MPa led to the conclusion that the optimum pressure lies between 15.9 and 20.7 MPa. Pressures in excess of 20.7 MPa did not significantly enhance the recovery of cdl.

Pooled cdl from supercritical toluene extractions of Forestburg coal at temperatures ranging from 350 to 450°C and pressures ranging from 7.6 to 13.1 MPa was analyzed using standard techniques. Solvent analysis showed that the cdl consists of about 50% pentane soluble material (oil or maltene), 25% asphaltene, 10% preasphaltene and about 10% tetrahydrofuran insoluble residue. The oil had an average molecular weight of 267 and a H/C ratio of 1.37 (0.78 for the starting coal). Liquid chromatography of the oil shows that polar compounds make up 32% of the total oil.

APPLICATION AND ONGOING WORK

Further work is ongoing. This contract is a continuation of Contract No. 8-9091 and 9-9169.

TITLE: CHARACTERIZATION OF SOLID RESIDUES FROM COAL LIQUEFACTION PROCESSES - PHASE 2

CONTRACTOR: University of Regina	FILE NUMBER: 0-9160	FUNDING	
	BEGIN/END: June 81/March 82	CANMET:	$67 465
CANMET	ENERGY TECHNOLOGY ACTIVITY	CONTRACTOR:	--
SCIENTIFIC	SUB-ACTIVITY: Coal	OTHER:	--
AUTHORITY: J.T. Price	TECHNOLOGY: Liquefaction	TOTAL:	$67 465

OBJECTIVES

1. Investigate microscopically the feed materials and residues generated by CANMET contractors in the coal liquefaction program. Residuals analyzed microscopically came from studies of:
   a) the hydrogenation of various coal ranks with antracene oil and other solvents;
   b) catalytic liquefaction of coal;
   c) the supercritical gas extraction of coal.
2. Examine relationships between feedstock composition, liquid yields and solid products.
3. Measure the efficiency of the liquefaction processes by evaluating, optically, the amounts of coal versus solvent-derived materials in the solid residues.

PROCEDURE

Samples were prepared for optical analysis according to ASTM procedures. Reflectance measurements were recorded and qualitative analyses were performed on feedstocks using ICCP techniques. Residual particles were classified firstly according to whether they were isotropic or anisotropic and further subdivided according to morphological character. SEM-EDAX trace element analyses were done on selected samples to correlate optical microscope and SEM results and to help identify the nature of the origin of the residues.

RESULTS

Optical properties of liquefaction residues varied with feedstocks and processing conditions. THF insoluble residues, produced by hydrogenation of sub-bituminous coal or lignite in anthracene oil, displayed isotropic amorphous carbon interspersed with an abundance of finely divided mineral matter. Higher reaction temperatures produced more anisotropic carbon at the same pressures. More unaltered coal, mineral matter and semi-coke, but less isotropic carbon, were derived from sub-bituminous coals. Studies with catalytic hydrogenation of high inertinite bituminous coals also showed the principal residue constituent to be isotropic carbon interspersed with minute mineral matter. Some unaltered and altered inertinite coal macerals could be identified. The amount of unaltered coal decreased with longer residence times. Anisotropic semi-coke was more pronounced at higher temperatures, higher solvent/coal ratios, and longer residence times. The use of various catalysts altered the relative amounts of the constituents in the residue. Studies of supercritical gas extraction of coal showed that the effectiveness of certain H-donor solvents could be detected petrographically, but tetralin/toluene could not. SEM-EDAX trace element analyses agreed well with petrographic data and were particularly useful for identifying the nature of isotropic carbon structures.

APPLICATION AND ONGOING WORK

Microscopic characterizations of the source and nature of the materials that do not liquefy, derived from CANMET-sponsored liquefaction projects, are being continued at the University of Regina in 1982/83. Such studies are essential for optimizing coal conversion processes.

SUPPORTING DOCUMENTS

Final report: "Characterization of Solid Residues from Coal Liquefaction Processes - Phase 1". File No. 9-9177.

TITLE: DEVELOPMENT OF NOVEL METHODS OF OXYGEN REMOVAL FROM COALS

CONTRACTOR:	SNC Ltd.	FILE NUMBER:	8-9090	FUNDING	
		BEGIN/END:	Aug. 79/Dec. 81		
				CANMET:	$38 000
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	—
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	—
AUTHORITY:	Dr. E. Furimsky	TECHNOLOGY:	Liquefaction	TOTAL:	$38 000

OBJECTIVES

Develop novel methods of oxygen removal from low rank coals to increase the heating value as well as the liquefaction properties of the coals.

PROCEDURE

Treatment of coal samples with aqueous solutions of various reducing agents at temperatures of 150 and 250°C.

Ultimate analysis of the untreated and treated samples.

RESULTS

Of several reducing agents, only ferrous sulphate had desirable effects. Thus, substantial removal of oxygen from a lignite was achieved.

APPLICATION AND ONGOING WORK

The developed approach is now being applied to oxygen removal from several low rank coals. Also, different iron salts are being tested as potential reducing agents.

TITLE: PREPARATION AND TESTING OF COAL-OIL MIXTURES FOR COMBUSTION BY CONTINUOUS GRINDING OF COAL IN OIL

CONTRACTOR:	General Comminution Inc.	FILE NUMBER:	9-9166	FUNDING	
		BEGIN/END:	April 80/June 82		
				CANMET:	$72 014
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	72 014
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	G.N. Banks	TECHNOLOGY:	Combustion	TOTAL:	$144 028

OBJECTIVES

Obtain sufficient performance and scale-up data to prepare a functional design of a commercial-size Szego mill to be used for preparing industrial or utility boiler coal-liquid mixtures.

PROCEDURE

1. Obtain performance data with the existing laboratory mill, using New Brunswick Minto coal and Alberta Coal Valley coal in mixtures with No. 4 and No. 6 fuel oil as well as with water.
2. Design and build a larger prototype mill.
3. Carry out grinding tests with this larger mill to confirm and improve the correlations for scale-up parameters.
4. Devise appropriate scale-up strategy.
5. Prepare functional design of a commercial-size mill, including an estimate of its manufacturing cost.

RESULTS

1. More than 250 experimental runs were carried out in the existing 22 cm diameter mill. The data obtained from these runs confirmed data obtained in earlier experiments.
2. A 45 cm diameter mill, capable of treating 1 to 4 tonnes of coal per hour was designed and constructed.
3. Experiments performed in the larger mill indicate that peripheral speeds of 600 rpm will give results that are similar to data obtained in the smaller mill, operating at 1200 rpm.
4. Although the Szego mill does not have an industrial-use track record and its maintenance costs are therefore uncertain, it does appear (because of its low complexity and safety of operation) to be superior to the ball mill and agitated media mills for the preparation of coal-liquid mixtures.
5. The estimated manufacturing cost of a commercial-size Szego mill, with an operating capacity of 5 to 30 t/h, is $150 000.

APPLICATION AND ONGOING WORK

Industrial interest in the Szego mill for grinding coal-liquid mixtures is increasing, especially in applications where fine or ultrafine grinding is required. It is expected that General Comminution Inc. will require an industrial user (e.g., Ontario Hydro) to further develop and evaluate the mill.

TITLE: POTENTIAL COAL-LIQUID MIXTURE FUEL UTILIZATION IN CANADA - PHASE 1

CONTRACTOR:	Montreal Engineering Company Ltd.	FILE NUMBER:	1-9080	FUNDING	
		BEGIN/END:	Oct. 81/Aug. 82		
				CANMET:	$19 000
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	H. Whaley	TECHNOLOGY:	Combustion	TOTAL:	$19 000

OBJECTIVES

1. Produce an inventory of oil burning equipment used in utility boilers, industrial boilers and process combustors in the province of Nova Scotia. The survey will include all installations rated above 5.86 MW thermal input.

2. Provide data on fuel resources and regulations and emissions standards pertaining to coal and oil utilization in Nova Scotia.

PROCEDURE AND RESULTS

Liaison with Provincial Government Departments, Crown Agencies, industry associations and private corporations are required to provide the necessary data. Montreal Engineering was required to provide complete data on the province of Nova Scotia as follows:

1. Fuel resources (coal and oil), fuel transportation and CLM preparation plants.

2. Inventory of oil-burning equipment in the following categories:

   a) Utility boilers, oil-fired and;
      - coal designed
      - oil designed, future coal capable
      - oil designed, liberal design
      - oil designed, compact design

   b) Industrial boilers, oil-fired and;
      - coal designed
      - oil designed, package firetube
      - oil designed, package watertube
      - oil designed, modular and field erected

   c) Industrial process combustors, oil-fired and;
      - coal designed
      - oil designed

3. Environmental emissions data. Established and recorded the local (provincial) regulations with respect to environmental factors of CLM fuel utilization. In addition, recorded the equivalent federal environmental guidelines and compared both regional and national standards from the viewpoint of oil replacement by coal-liquid mixtures.

APPLICATION AND ONGOING WORK

This contract is part of the IEA CLM Cooperation Agreement on assessment and planning for coal-liquid mixture technology utilization signed by the USA, the Netherlands, Sweden, Japan and Canada. Also part of the ongoing EMR technology development program.

SUPPORTING DOCUMENTS

Final report: "Assessment of Potential Coal-Liquid Mixture Fuel Utilization in Canada - Phase 1".

TITLE: COAL-OIL-WATER MIXTURE COMBUSTION TESTS AT THE IRON ORE CO. OF CANADA, SEPT-ILES, QUEBEC

CONTRACTOR:	Compagnie Minière, I.O.C.	FILE NUMBER:	2-9090	FUNDING	
		BEGIN/END:	July 82/Feb. 83		
				CANMET:	$105 141
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	49 184
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	G.N. Banks	TECHNOLOGY:	Combustion	TOTAL:	$154 325

OBJECTIVES

1. Show that a coal-liquid slurry fuel will remain homogeneous after truck transportation of several hundred miles.
2. Demonstrate that the coal-liquid mixture can be handled like a standard heavy fuel oil.
3. Evaluate the CLM as a substitute for Bunker 'C' (No. 6) oil in drying of Schefferville iron ore.

PROCEDURE

1. The fuel was shipped in six tanker-trucks from Shelbyville, Kentucky to Champlain, N.Y., where it was transferred to 3 larger Canadian tank-trailers and shipped to Sept-Iles, Que. These 3 reservoirs were maintained at 60°C, by means of steam-heating coils.
2. The fuel was transferred to a 4545 L day-tank, as required, where the temperature was increased to 121°C prior to combustion. A Forney-Verloop burner was used to burn the fuel.
3. Between July 20 and 23, 1982. 97 720 L of CLM fuel was used to dry Schefferville iron ore in a rotary kiln. This fuel was fired for 47.75 h at an average fuel rate of 2045 L/h. The kiln was operated under the same conditions as when Bunker 'C' oil was used.

RESULTS

1. Stability of the CLM fuel remained unaffected during long-distance transportation.
2. This test burn demonstrated that CLM fuel can be substituted for Bunker 'C' oil in existing equipment without major alterations. Dual-fuel firing can be retained if fuel flexibility is required.
3. CLM fuel was shown to be an acceptable substitute for No. 6 fuel oil in the ore dryer.

APPLICATION AND ONGOING WORK

The concept of burning CLM has been successfully developed and I.O.C. has proposed a three-week test (105 h) at a total cost of $434K. They have also prepared a cost evaluation for a 30-day test (720 h) at a total cost of $866K. It was originally proposed that the three-week test take place in the spring of 1983 but this has been postponed at least until the winter of 1983/84.

SUPPORTING DOCUMENTS

Final report: "COM Combustion Test, an I.O.C./EMR Cooperative Evaluation".

TITLE: ELECTRON MICROPROBE ANALYSIS OF MACERALS IN CANADIAN COALS

CONTRACTOR:	University of Ottawa	FILE NUMBER:	1-9047	FUNDING	
		BEGIN/END:	July 81/March 82		
				CANMET:	$4 500
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	B.N. Nandi	TECHNOLOGY:	Combustion	TOTAL:	$4 500

OBJECTIVES

In situ microprobe analysis of coals with secondary and back-scattered electron source in order to assess the mineral matter distribution of different macerals. The presence of some of the minerals is detrimental to coal combustion.

PROCEDURE

Preparation of coal samples, chemical and physical analysis, proximate analysis, ash analysis, calorific value and free swelling index determination. Petrographic analysis by ASTM Method.

Mineral matter distributions in different coal macerals (vitrinite, exinite, and inertinite) were determined by Cambridge Mark V Microprobe and Ortec Energy Dispersive System.

RESULTS

During the study, it was evident that a Cambridge Mark V Microprobe analyzer, without any optical microscopic facilities, would be insufficient to assess values quantitatively. The Cambridge instrument is not suitable for this type of work.

TITLE: FLUIDIZED BED EVAPORATION OF COAL CAKE CONTAINING PETROLEUM CRUDE OIL

CONTRACTOR:	Integ Intercontinental Engineering Ltd.	FILE NUMBER:	0-9075	FUNDING	
		BEGIN/END:	June 81/June 82		
				CANMET:	$122 754
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	M. Skubnik	TECHNOLOGY:	Slurry Transport	TOTAL:	$122 754

OBJECTIVES

At the terminal of a long-distance coal-oil slurry pipeline system, valuable petroleum should be completely recovered from the slurry. Consequently, coal-oil cakes, containing considerable amounts of oil, may yield additional oil when subjected to thermal evaporation .

Using a Fluidized Bed Evaporator (FBE), designed and constructed by CANMET, the objectives are:

1. Assemble and improve the FBE system by purchasing, constructing, and installing a K-Tron feeder and an off-gas condenser.
2. Verify predetermined conditions of evaporation leading towards less than 2% oil in the coal products.
3. Prepare representative samples of the condensates and the coking and thermal coal products.

PROCEDURE

1. Assembly and improvement of the FBE

   The FBE consists of a reactor (D = 0.1 m), fluidizing gas (N_2), and shell heaters, cyclones, coal product collectors, and controls. When equipped with the K-Tron feeder (LWF-25) and the condenser, the FBE will handle up to 20 kg feed per hour and will decrease crude oil content from 12% to less than 2% at bed temperature below 300°C.

2. Verification of predetermined conditions

   a) Prepare model coking coal-syncrude oil cakes (12% oil).
   b) Run evaporation tests.
   c) Evaluate coking coal products for caking properties and oil content.

3. Preparation of coal product and condensate samples

   a) Use model coking coal-syncrude oil cakes.
   b) Use two subbituminous coal-syncrude oil cakes and one coking coal-syncrude oil cake, obtained by simulated pipeline slurry centrifuging.

RESULTS

Coking coal (McIntyre coal)

1. Predetermined evaporation conditions were generally verified with a minimum coal product oil content of 1.3%.
2. Caking properties of coal did not change at bed/windbox temperatures of 291/396°C, but deteriorated at 252/472°C.
3. Maximum of 90% of the cake oil evaporated at a bed temperature of 291°C.
4. Oil content of coal product varied almost exclusively with bed temperature.

Subbituminous coals (Wabamun and Vesta coals)

1. Oil evaporation was easier; almost 97% of the oil was removed at 237°C (Wabamun) and Vesta coal indicated a similar trend. Coal product oil content was as low as 0.2%.
2. Simultaneous water evaporation resulted in less than 1% moisture content in the products.

Confirmation of the technical feasibility of oil evaporation will still require completion of coal products and condensate evaluations.

APPLICATION AND ONGOING WORK

Applicability of this concept depends on the overall feasibility of coal-oil slurry transportation and specifically on the primary (mechanical) coal-oil slurry separation, degree of oil contamination by coal, and the effect of contaminants on oil refining.

TITLE: DESIGN OF A HIGH-TEMPERATURE EROSION TEST FACILITY - PHASE 1

CONTRACTOR:	Montreal Engineering Company Ltd.	FILE NUMBER:	1-9001	FUNDING	
		BEGIN/END:	Oct. 81/July 82		
				CANMET:	$30 000
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Coal	OTHER:	--
AUTHORITY:	A. Lui	TECHNOLOGY:	Materials for Coal Handling and Conversion	TOTAL:	$30 000

OBJECTIVES

The objective is to design a high-temperature corrosion-erosion testing facility for characterization of materials used in fluidized bed coal combustion and coal gasification systems.

PROCEDURE

The contractor studied the existing facilities in the USA and produced a conceptual design for discussion. Finally, a detailed design of the unit was made.

RESULTS

The unit designed by the contractor is capable of operating with gas temperature up to 1000°C and particle velocity up to 65 m/s. Twelve metal specimens of 1.5 x 2 cm can be studied at a time with the angle of impingement varying from 0 to 90°. A rotating disc was devised to measure the velocities of the particles. The unit can be used for corrosive gas containing SO_2, CO and CO_2 mixtures.

APPLICATION AND ONGOING WORK

A unit, with some modification of the above design, will be built. It will be used to study the performance of materials in the convective pass in the fluidized bed coal combustor.

ENERGY TECHNOLOGY

NUCLEAR ENERGY

TITLE: BENCH-SCALE EVALUATION OF THE TECHNICAL AND ECONOMIC FEASIBILITY OF USING ION EXCHANGE TECHNIQUES TO ISOLATE RADIONUCLIDES FROM PROCESSING OF URANIUM ORES

CONTRACTOR:	Eldorado Nuclear Ltd.	FILE NUMBER:	9-9054	FUNDING	
		BEGIN/END:	Nov. 79/March 80		
				CANMET:	$13 027
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	13 027
SCIENTIFIC		SUB-ACTIVITY:	Nuclear Energy	OTHER:	--
AUTHORITY:	G.M. Ritcey	TECHNOLOGY:	Processing of Radioactive Ores	TOTAL:	$26 054

OBJECTIVES

Bench-scale evaluation of the technical and economic feasibility of using ion exchange techniques to isolate radionuclides, including Radium 226, from mill sulphate and carbonate effluents from conventionally processed uranium ores.

PROCEDURE

Examine each of several possible ion exchange resins for its radionuclide removal ability. The data will provide a guide as to the:

1. Feasibility of using ion exchange
2. Type of resin to be used
3. Loading data

Results to be assessed on the basis of technical and practical feasibility and cost estimates made.

RESULTS

Results indicated that removal of soluble Ra^{226} down to a level of <3 pCi/L by ion exchange is technically feasible. Barite had the highest sorbent capacity. A once-through process using ion exchange is not economically viable because of the low loading capacity. The cost of the resin alone would be $8.00-$30.00/kg U produced, or $6.60-$25.00/1000 L of effluent treated, when using IR-122 or IRC-50.

APPLICATION AND ONGOING WORK

Work at CANMET, based on the contract results and later information, is in progress.

ENERGY TECHNOLOGY

RENEWABLE ENERGY

TITLE: DEVELOPMENT OF A HEAT STORAGE SYSTEM FOR DOMESTIC APPLICATIONS USING A FUSED SALT HYDRATE AS A STORAGE MEDIUM

CONTRACTOR:	New Brunswick Research and Productivity Council	FILE NUMBER:	8-9042	FUNDING	
		BEGIN/END:	Jan. 79/March 80		
				CANMET:	$32 220
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Renewable Energy	OTHER:	--
AUTHORITY:	Dr. V. Mirkovich	TECHNOLOGY:	Materials for Advanced Energy Conversion Systems	TOTAL:	$32 220

OBJECTIVES

The objective was the development of a heat storage system for domestic application using a fused salt hydrate as a storage medium. The salt hydrate is to be contained in the interstices of a porous ceramic material, which is to be encapsulated within an impermeable covering layer.

PROCEDURE

The stability of sodium thiosulphate pentahydrate in contact with clay surfaces was studied and its crystallization habit in restricted volume determined. The salt hydrate impregnated ceramic specimens were encapsulated and the durability of the encapsulations examined. The latent heat capacity of the salt hydrate/brick composites was measured by the method of cooling curves.

RESULTS

This study has shown the accuracy of the basic concept, but it has also demonstrated that the problem is more complex than originally believed. To obtain desired results, at least three distinct but interrelated factors should be studied further:

1. Characteristics of various phase-changing salts and the problem of supercooling
2. Development of ceramic bodies resistant to the attack of these salts
3. Development of an encapsulating material/system compatible with both 1 and 2.

APPLICATION AND ONGOING WORK

Further studies on this project have been temporarily suspended.

TITLE: DEVELOPMENT OF SEMICONDUCTOR FILMS FOR PHOTOELECTROCHEMICAL PRODUCTION OF HYDROGEN OR ELECTRICITY USING SOLAR ENERGY

CONTRACTOR:	Bell Northern Research Ltd.	FILE NUMBER:	9-9094	FUNDING	
		BEGIN/END:	June 80/June 81		
				CANMET:	$177 818
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Renewable Energy	OTHER:	--
AUTHORITY:	S.M. Ahmed	TECHNOLOGY:	Materials for Advanced Energy Conversion Systems	TOTAL:	$177 818

OBJECTIVES

Prepare and characterize thick semiconducting TiO_2 films for application as photoanodes in photoelectrolysis of water, using sunlight to produce hydrogen.

PROCEDURE

The TiO_2 films, in the 15-30 μm range, were screen-printed on a metal backed Al_2O_3 substrate. The starting material was anatase or a mixture of anatase and rutile paste containing other dopants where necessary. The films were dried, fired, and sintered at controlled temperatures in an inert atmosphere, and finally reduced by hydrogen to the required degree.

The physical properties, such as structure, hardness, adhesion, electrical resistance, film composition, etc., were investigated using a number of techniques. The films were supplied to CANMET for photoelectrohemical work.

RESULTS

A large number of films were prepared under a variety of experimental conditions in order to establish a relationship between screen-printing parameters and the photoelectrochemical response.

The films prepared under certain controlled conditions proved to be as good as single crystal TiO_2 in photon conversion efficiency, and sometimes even better. The films are easy to make and the process can also be scaled-up easily.

CANMET's in-house work has shown that these films are stable and yielded 2% efficiency in solar to hydrogen energy conversion.

APPLICATION AND ONGOING WORK

Extensive in-house work has been carried out by CANMET on the application of these films for photoelectrolysis of water. Applications have been filed through CPDL (Canadian Patents and Development Ltd.) for patenting the process in Canada and the U.S.A.

CANMET is planning further work to improve the efficiency of these films for photoelectrochemical energy conversion by modifying the solid state properties.

TITLE: DEVELOPMENT OF NONDESTRUCTIVE TESTING TECHNIQUES TO EVALUATE THE INTEGRITY OF SINTERED SOLID-STATE ELECTROLYTES - PHASE 1

CONTRACTOR:	McMaster University	FILE NUMBER:	0-9006	FUNDING	
		BEGIN/END:	Aug. 80/June 82		
				CANMET:	$47 052
CANMET		ENERGY TECHNOLOGY ACTIVITY		CONTRACTOR:	--
SCIENTIFIC		SUB-ACTIVITY:	Renewable Energy	OTHER:	--
AUTHORITY:	Dr. T.A. Wheat	TECHNOLOGY:	Materials for Advanced Energy Conversion Systems	TOTAL:	$47 052

OBJECTIVES

Detection and characterization of 50 micrometre sized sub-surface flaws in sintered ceramic electrolytes.

PROCEDURE

Develop a variety of ultrasonic transducers, having different beam shapes and frequencies, together with an automated X-Y-Z scanning system so that material can be examined fully automatically, and the co-ordinates of defects automatically logged and rescanned on demand.

RESULTS

The contractor has succeeded in lowering the size limit of the smallest detectable defect from the current state-of-the-art figure of 75 micrometres to 27 micrometres. This was achieved using the hemispherical focussed transducers produced under this contract. However, the scanning rate is necessarily slow as the focus has to pass through n increments in the z-axis. In future, this should be avoided by the use of a screwdriver beam transducer which will log data for the full distance of the z-axis in one scan.

APPLICATION AND ONGOING WORK

The ultimate goal is the detection of 5 micrometre sized sub-surface defects in any solid. The immediate application is the development of high-quality solid electrolytes for use in batteries and fuel cells. The technology will have very wide application.

The development is continuing through a follow-on contract, File No. 2-9065.

OPINION POLL

The opinion of concerned readers may influence the direction of future CANMET research.

We invite your assessment of this report - No._____

Is it useful?	Yes_____	No_____
Is it pertinent to an industry problem?	Yes_____	No_____
Is the subject of high priority?	Yes_____	No_____

Comments_____

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Please mail to: CANMET Editor, EMR, 555 Booth Street, Ottawa, Ontario, K1A 0G1

A complimentary copy of the CANMET REVIEW describing CANMET research activity will be sent on request.

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